

## Supplementary Material – Data Mapping with PDML in PLAIN

### 1 Introduction

This document is part of the supplementary material for the publication "Mapping the Entire Record – An Alternative Approach to Data Access from Medical Logic Modules", published in Applied Clinical Informatics. It provides a small tutorial on data mapping with the approach described in the publication, to make it easier for the reader to understand by examples.

PLAIN is an experimental version of the HL7 Arden Syntax standard. In PLAIN, statements and operators can be used without a frame-like MLM structure, like in a scripting language. PLAIN supports an XML-based format termed PDML, which directly corresponds to its data type system. PLAIN provides a natively integrated PDML mapper, so access to PDML-encoded patient data is straightforward, as illustrated in the examples below. As in the Arden Syntax, data can be read into an MLM by means of a READ statement. The argument of a READ statement has to refer to either a file name or a network resource. The following examples generally access patient data from files. The PDML files have the file extension "xml", since PDML is XML-based.

The examples show how PDML-encoded patient data can be processed with PLAIN. They include screenshots showing details from an MLM authoring environment. The upper part of a screenshot shows the MLM code, the lower part shows the corresponding MLM output.

### 2 Examples for data access

#### 2.1 Elementary types

The most simple case would be to encode a single data item, such as a number. For example, the PDML representation of the number 123 is as follows ("number.xml"):

```
<number>123</number>
```

Processing this file with PLAIN is as follows (detail from "PLAIN Editor"):

```
1 data := READ "number.xml" ;
2 WRITE data ;
```

Output Error

123

## 2.2 Timestamps

The Arden Syntax has a timestamped data type system. In PDML, timestamps are encoded as XML attributes with the name "time". The above number with an associated timestamp can be encoded as follows ("number\_with\_time.xml"):

```
<number time="2019-08-15 17:30:00">123</number>
```

Processing this file with PLAIN is as follows:

```
1 data := READ "number_with_time.xml" ;
2 WRITE data ;
3 WRITE TIME OF data ;
```

Output Error

123  
2019-08-15 17:30:00

## 2.3 Lists

A time series can be encoded as a list ("time\_series.xml"):

```
<list>
  <number time="2019-08-04 15:21:00">130</number>
  <number time="2019-08-04 18:24:00">147</number>
  <number time="2019-08-04 21:10:00">137</number>
  <number time="2019-09-04 00:15:00">137</number>
</list>
```

Lists do not have a timestamp of their own. Accessing the time of a list returns the timestamps of its elements. Processing this file with PLAIN is as follows:

```
1 data := READ "time_series.xml" ;
2 WRITE data ;
3 WRITE TIME OF data ;
4 WRITE INCREASE OF data ;
```

Output Error

```
[130,147,137,137]
[2019-08-04 15:21:00,2019-08-04 18:24:00,2019-08-04 21:10:00,2019-09-04 00:15:00]
[17,-10,0]
```

Line 2 outputs the values, line 3 outputs the corresponding timestamps. Line 4 applies the INCREASE operator to calculate the increases between consecutive list elements.

In contrast to the Arden Syntax, PLAIN supports nested lists to ensure the algebraic closure of the data type system. Thus, it is possible to nest lists in the PDML representation. However, we would recommend to avoid this as it may lead to complicated code.

## 2.4 Objects

The object data type has been introduced in Arden Syntax version 2.5. Objects can be nested, enabling data structures of arbitrary complexity, such as CDS EMRs. A very simple example in the form of a patient object with the attributes "firstname", "lastname", and "bedposition" can be encoded as follows ("simple\_object.xml"):

```
<object type="patient">
  <attribute name="patientname">
    <string>John Doe</string>
  </attribute>
  <attribute name="birthdate">
    <time>1980-04-03</time>
  </attribute>
  <attribute name="bedposition">
    <string>Bed 4</string>
  </attribute>
</object>
```

Processing this file with PLAIN is as follows:

```

1 data := READ "simple_object.xml" ;
2 WRITE data.patientname ;
3 WRITE @table data;

```

Output Error

John Doe

patientname	John Doe
birthdate	1980-04-03 00:00:00
bedposition	Bed 4

Line 2 extracts the attribute "patientname" from the object, using the DOT operator. Line 3 applies a user-defined function, one of the extended features of PLAIN, to the object. The function "table" transforms lists and objects to an HTML table.

## 2.5 CDS EMRs

A CDS EMR is an object with a tree structure of arbitrary complexity. However, we would recommend keeping the structure as simple as possible. The file "cds\_emr.xml" contains a CDS EMR for a fictional patient. The included data is artificial, but reality-based. In clinical routine at UHER, CDS EMRs have the same basic structure, but more sections and measurements are included. An example CDS EMR is provided at the end of this tutorial.

```

1 record := READ "cds_emr.xml" ;
2 WRITE @table record.laboratory.bilirubin ;

```

Output Error

#	Value	Time
1	3.3	2019-08-03 17:23:00
2	4.1	2019-08-04 06:53:00
3	5.3	2019-08-05 07:06:00

Line 2 extracts the time series of bilirubin from the CDS EMR and displays it as a table. It may be reasonable to assign data items from CDS EMRs to variables, to avoid the need for repeated use of complete path expressions.

## 2.6 Semantic Interoperability with LOINC

As another experimental feature, PLAIN provides native support for LOINC to enable semantic interoperability. Elementary types, such as NUMBER, can be provided with a LOINC attribute. Thus, the meaning of 'glucose' is unambiguously defined as referring to 'Glucose [Mass/volume] in Serum or Plasma'. The following PDML example shows the time series from section 2.3, but with LOINC annotations.

```
<list>
  <number time="2019-08-04 15:21:00" loinc="2345-7">130</number>
  <number time="2019-08-04 18:24:00" loinc="2345-7">147</number>
  <number time="2019-08-04 21:10:00" loinc="2345-7">137</number>
  <number time="2019-09-04 00:15:00" loinc="2345-7">137</number>
</list>
```

PLAIN provides a LOINC operator to retrieve the value of the LOINC attribute. For a complex data structure, such as a CDS EMR, PLAIN provides an EXTRACT LOINC statement that searches all items in the data structure and returns all hits in the form of a list. For example, the following statement extracts all items with LOINC code 2345-7 from a CDS EMR.

```
glucose := EXTRACT LOINC "2345-7" FROM emr ;
```

In case a CDS EMR does not include any items with the specific LOINC code, the result of an EXTRACT LOINC statement is an empty list.

## 3 Content of "cds\_emr.xml"

```
<object type="cds_emr">
  <attribute name="record_creation_time">
    <time>2019-08-05 23:00:00</time>
  </attribute>
  <attribute name="demographics">
    <object>
      <attribute name="casenumber">
        <number>12345</number>
      </attribute>
      <attribute name="admission">
        <time>2019-08-03 09:26:00</time>
      </attribute>
      <attribute name="dismissal">
        <time>2019-08-05 22:10:00</time>
      </attribute>
      <attribute name="patientname">
        <string><![CDATA[Doe, Jane]]></string>
      </attribute>
    </object>
  </attribute>
</object>
```

```

</attribute>
<attribute name="birthdate">
  <time>1972-03-11</time>
</attribute>
<attribute name="gender">
  <string><![CDATA[female]]></string>
</attribute>
<attribute name="bedposition">
  <string><![CDATA[Bed 12]]></string>
</attribute>
</object>
</attribute>
<attribute name="ventilation">
  <object>
    <attribute name="etco2">
      <list>
        <number time="2019-08-03 14:06:24">35</number>
        <number time="2019-08-03 15:00:00">35</number>
        <number time="2019-08-03 16:00:00">35</number>
        <number time="2019-08-03 17:00:00">36</number>
        <number time="2019-08-03 18:00:00">34</number>
        <number time="2019-08-03 19:00:00">36</number>
        <number time="2019-08-03 20:00:00">34</number>
        <number time="2019-08-03 21:00:00">38</number>
        <number time="2019-08-03 22:00:00">41</number>
        <number time="2019-08-03 23:00:00">37</number>
        <number time="2019-08-04 00:00:00">38</number>
        <number time="2019-08-04 01:00:00">38</number>
        <number time="2019-08-04 02:00:00">36</number>
        <number time="2019-08-04 03:00:00">36</number>
        <number time="2019-08-04 04:00:00">37</number>
        <number time="2019-08-04 05:00:00">40</number>
        <number time="2019-08-04 05:59:00">39</number>
        <number time="2019-08-04 07:00:00">38</number>
        <number time="2019-08-04 08:00:00">40</number>
        <number time="2019-08-04 09:00:00">44</number>
        <number time="2019-08-04 10:00:00">49</number>
        <number time="2019-08-04 11:00:00">49</number>
        <number time="2019-08-04 12:00:00">49</number>
        <number time="2019-08-04 13:00:00">50</number>
        <number time="2019-08-04 14:00:00">50</number>
        <number time="2019-08-04 15:00:00">48</number>
        <number time="2019-08-04 16:00:00">50</number>
        <number time="2019-08-04 17:00:00">52</number>
        <number time="2019-08-04 18:00:00">54</number>
        <number time="2019-08-04 19:00:00">57</number>
        <number time="2019-08-04 20:00:00">54</number>
        <number time="2019-08-04 21:00:00">51</number>
        <number time="2019-08-04 22:00:00">50</number>
        <number time="2019-08-04 23:00:00">52</number>
        <number time="2019-08-05 00:00:00">56</number>
        <number time="2019-08-05 01:00:00">45</number>
        <number time="2019-08-05 02:00:00">40</number>
        <number time="2019-08-05 03:00:00">35</number>
        <number time="2019-08-05 04:00:00">34</number>
        <number time="2019-08-05 05:00:00">34</number>
        <number time="2019-08-05 06:00:00">34</number>
        <number time="2019-08-05 06:54:00">35</number>
        <number time="2019-08-05 08:00:00">35</number>
        <number time="2019-08-05 09:00:00">34</number>
        <number time="2019-08-05 10:00:00">34</number>
        <number time="2019-08-05 11:00:00">34</number>
        <number time="2019-08-05 11:31:00">33</number>
        <number time="2019-08-05 12:00:00">33</number>
      </list>
    </attribute>
  </object>
</attribute>

```



```

        <number time="2019-08-05 17:59:00">22</number>
        <number time="2019-08-05 19:00:00">23</number>
        <number time="2019-08-05 20:00:00">23</number>
    </list>
</attribute>
<attribute name="peep">
    <list>
        <number time="2019-08-03 14:00:00">10</number>
        <number time="2019-08-03 15:00:00">9.4</number>
        <number time="2019-08-03 16:00:00">9.3</number>
        <number time="2019-08-03 17:00:00">9.2</number>
        <number time="2019-08-03 18:00:00">9.3</number>
        <number time="2019-08-03 19:00:00">9.3</number>
        <number time="2019-08-03 20:00:00">9.4</number>
        <number time="2019-08-03 21:00:00">9.3</number>
        <number time="2019-08-03 22:00:00">9.4</number>
        <number time="2019-08-03 23:00:00">9.2</number>
        <number time="2019-08-04 00:00:00">9.3</number>
        <number time="2019-08-04 01:00:00">9.2</number>
        <number time="2019-08-04 02:00:00">9.3</number>
        <number time="2019-08-04 03:00:00">9.2</number>
        <number time="2019-08-04 04:00:00">9.3</number>
        <number time="2019-08-04 05:00:00">9.3</number>
        <number time="2019-08-04 05:59:00">9.3</number>
        <number time="2019-08-04 07:00:00">9.3</number>
        <number time="2019-08-04 08:00:00">9.2</number>
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        <number time="2019-08-04 11:00:00">8.3</number>
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        <number time="2019-08-04 15:00:00">8.4</number>
        <number time="2019-08-04 16:00:00">8.2</number>
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        <number time="2019-08-05 04:00:00">8.5</number>
        <number time="2019-08-05 05:00:00">8.2</number>
        <number time="2019-08-05 06:00:00">8.4</number>
        <number time="2019-08-05 06:59:00">8.4</number>
        <number time="2019-08-05 08:00:00">8.3</number>
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        <number time="2019-08-05 10:00:00">8.3</number>
        <number time="2019-08-05 11:31:00">6.4</number>
        <number time="2019-08-05 13:00:00">6.5</number>
        <number time="2019-08-05 14:00:00">6.3</number>
        <number time="2019-08-05 15:00:00">6.2</number>
        <number time="2019-08-05 16:00:00">6.4</number>
        <number time="2019-08-05 17:16:00">6.3</number>
        <number time="2019-08-05 17:59:00">6.4</number>
        <number time="2019-08-05 19:00:00">6.3</number>
        <number time="2019-08-05 20:00:00">6.2</number>
    </list>
</attribute>
<attribute name="tidalvolume">

```



```
<list>
  <number time="2019-08-03 14:00:00">385</number>
  <number time="2019-08-03 15:00:00">387</number>
  <number time="2019-08-03 16:00:00">378</number>
  <number time="2019-08-03 17:00:00">369</number>
  <number time="2019-08-03 18:00:00">387</number>
  <number time="2019-08-03 19:00:00">396</number>
  <number time="2019-08-03 20:00:00">412</number>
  <number time="2019-08-03 21:00:00">386</number>
  <number time="2019-08-03 22:00:00">375</number>
  <number time="2019-08-03 23:00:00">411</number>
  <number time="2019-08-04 00:00:00">389</number>
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  <number time="2019-08-04 03:00:00">413</number>
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  <number time="2019-08-04 05:00:00">420</number>
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  <number time="2019-08-05 06:59:00">373</number>
  <number time="2019-08-05 08:00:00">377</number>
  <number time="2019-08-05 09:00:00">364</number>
  <number time="2019-08-05 10:00:00">378</number>
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</attribute>
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  <list>
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    <number time="2019-08-03 16:00:00">50</number>
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    <number time="2019-08-03 18:00:00">40</number>
  </list>
</attribute>
```

```

<number time="2019-08-03 19:00:00">40</number>
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<number time="2019-08-04 01:00:00">40</number>
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<number time="2019-08-05 14:00:00">30</number>
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<number time="2019-08-05 17:16:00">30</number>
<number time="2019-08-05 17:59:00">30</number>
<number time="2019-08-05 19:00:00">30</number>
<number time="2019-08-05 20:00:00">30</number>
</list>
</attribute>
</object>
</attribute>
<attribute name="laboratory">
<object>
<attribute name="pct">
<list>
<number time="2019-08-03 17:23:00">3.7</number>
<number time="2019-08-04 06:53:00">2.48</number>
<number time="2019-08-05 07:06:00">1.39</number>
</list>
</attribute>
<attribute name="leukocytes">
<list>

```

```

        <number time="2019-08-03 17:28:00">29.23</number>
        <number time="2019-08-04 05:51:00">21.53</number>
        <number time="2019-08-05 05:35:00">19.78</number>
    </list>
</attribute>
<attribute name="thrombocytes">
    <list>
        <number time="2019-08-03 17:28:00">172</number>
        <number time="2019-08-04 05:51:00">171</number>
        <number time="2019-08-05 05:35:00">173</number>
    </list>
</attribute>
<attribute name="bilirubin">
    <list>
        <number time="2019-08-03 17:23:00">3.3</number>
        <number time="2019-08-04 06:53:00">4.1</number>
        <number time="2019-08-05 07:06:00">5.3</number>
    </list>
</attribute>
<attribute name="inr">
    <list>
        <number time="2019-08-03 17:28:00">1.75</number>
        <number time="2019-08-04 05:51:00">1.46</number>
        <number time="2019-08-04 12:55:00">1.57</number>
        <number time="2019-08-04 19:57:00">1.44</number>
        <number time="2019-08-05 05:35:00">1.68</number>
        <number time="2019-08-05 12:56:00">1.68</number>
    </list>
</attribute>
</object>
</attribute>
<attribute name="bga">
    <object>
        <attribute name="glucose">
            <list>
                <number time="2019-08-03 10:05:00">53</number>
                <number time="2019-08-03 13:56:00">95</number>
                <number time="2019-08-03 13:59:00">97</number>
                <number time="2019-08-03 14:09:00">73</number>
                <number time="2019-08-03 16:05:00">106</number>
                <number time="2019-08-03 17:19:00">118</number>
                <number time="2019-08-03 19:29:00">130</number>
                <number time="2019-08-03 22:27:00">138</number>
                <number time="2019-08-03 23:59:00">126</number>
                <number time="2019-08-04 02:30:00">125</number>
                <number time="2019-08-04 05:13:00">120</number>
                <number time="2019-08-04 09:48:00">110</number>
                <number time="2019-08-04 09:55:00">115</number>
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